BRITISH COLUMBIA

ACID RAIN PROGRAM : A Brief Overview

WASTE MANAGEMENT BRANCH

VICTORIA, B.C.

1985

Province of British Columbia

Ministry of Environment

INTRODUCTION

In 1982, spurred on by the problems of acid rain identified in eastern North America and Europe, the British Columbia Ministry of Environment initiated a program to determine the nature of acidic loading and its impact on the environment. This relatively new program has involved:

- monitoring precipitation chemistry,
- determining the sensitivity of lakes to acidic loading,
- initiating longterm lake chemistry monitoring,
- determining soil and geology sensitivity to acidic loading,
- constructing emission inventories for sulphur dioxide and nitrogen oxides.

The program will also involve determination of buffering capacity of characteristic soils, establishment of wet sulphate deposition criteria suitable for British Columbia environments and, together with the other western provinces, investigation of the current capability to model mesoscale transport and dispersion of acid causing pollutants.

This booklet provides an overview of the major activities of the British Columbia acid rain program along with a list of individuals to contact for more detailed information.

PRECIPITATION CHEMISTRY MONITORING

In early 1977, as part of the Canadian Network for Sampling Precipitation Chemistry (CANSAP), seven federal precipitation chemistry monitoring stations were established in British Columbia; an eighth station has since been added. With the exception of the station at Vancouver (see Table 1), the early indication was that acid precipitation was not a serious problem.

TABLE 1

Summary of Precipitation pH for British Columbia

Station	Average pH	pH Range	Years of Data
1. Victoria	4.5	3.7 - 4.9	5
2. Vancouver*	4.7	4.3 - 7.2	7
3. Kitimat	4.9	4.3 - 5.9	3
4. Port Hardy*	5.0	4.3 - 6.9	7
5. Terrace*	5.1	4.4 - 6.9	7
6. Kelowna*	5.1	4.3 - 7.6	7
7. Fort St. John*	5.2	4.3 - 7.3	7
8. Revelstoke*	5.2	4.7 - 6.1	5
9. Fort Nelson*	5.4	4.8 - 7.2	7
10. Prince George*	5.6	4.9 - 7.5	7
11. Smithers	6.0	4.9 - 7.3	3
12. Dawson Creek	6.1	5.0 - 7.5	3
13. Cranbrook	6.3	4.9 - 8.3	3
14. Kamloops	6.5	4.7 - 7.5	3

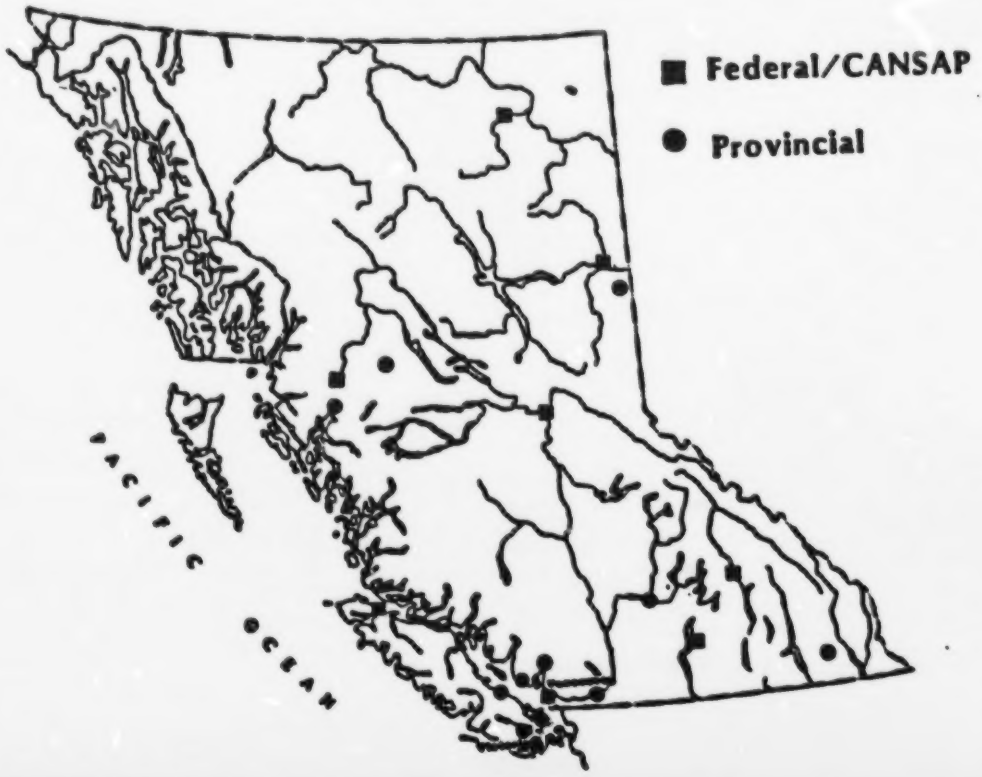
*indicates a CANSAP station

British Columbia's coastal environment and its numerous mountain ranges combine to produce tremendous gradients in climate, especially precipitation amount. As such, in 1983 the province established an additional six precipitation chemistry monitoring stations to ensure adequate coverage of all the various regions within the province. These additional stations are listed in Table 1.

The combined network of federal and provincial precipitation chemistry stations continued to point to the Vancouver-Victoria area as the principal problem area. To further elucidate the problem the province established a further seven stations around the Strait of Georgia (see Network map). So far the data suggest that the depressed pH is a regional problem (see Table 2) especially pronounced in urban locations and the southern Strait of Georgia area. The incidences of very low precipitation pH tend to correspond to occasions with small precipitation amounts (1-3 mm). A longer time series is needed before the full extent of the problem can be delineated and probable causes identified.

British Columbia

Precipitation Chemistry Network



Wet sulphate deposition is moderately high at coastal stations. In particular, annual wet sulphate deposition for Vancouver, Victoria, Kitimat and Port Hardy has been calculated to be 20.3, 18.7, 13.4 and 10 kg/ha respectively, including the correction for sea salt. At the interior stations wet sulphate deposition is considerably lower averaging less than 10 kg/ha/y.

TABLE 2

Classification of Precipitation Acidity in British Columbia

LOCATION	PERIOD	FREQUENCY OF OCCURRENCE (%)				AVERAGE pH FOR THE PERIOD
GEORGIA STRAIT NETWORK		NORMAL	SLIGHTLY ACIDIC	MODERATELY ACIDIC	STRONGLY ACIDIC	
VICTORIA/ QUADRA	Dec 83-May 85	2	21	63	14	4.48
VICTORIA/ KING ROAD	Mar 85-May 85	0	25	62.5	12.5	4.52
PENDER ISLAND	Aug 84-May 85	18	39	31	12	4.76
SPECTACLE LAKE	Mar 85-May 85	43	43	14	0	4.90
SQUAMISH	Oct 84-May 85	13	41	46	0	4.74
AGASSIZ	Oct 84-May 85	93	7	0	0	5.52
PARKSVILLE (NANOOSE)	Mar 85-May 85	50	50	0	0	5.43
SMITHERS	Jan 84-May 85	98	2	0	0	6.03
TERRACE	Dec 83-Apr 85	71	29	0	0	5.21
KITIMAT	Jan 83-Jun 85	42	36	22	0	4.92
DAWSON CREEK	Jan 84-May 85	100	0	0	0	6.18
CRANBROOK	Jan 84-Jun 85	100	0	0	0	6.30
KAMLOOPS	Feb 84-Jun 85	92	8	0	0	6.50

	pH
Normal	> 5.0
Slightly acidic	4.7 - 5.0
Moderately acidic	4.3 - 4.6
Strongly acidic	< 4.3

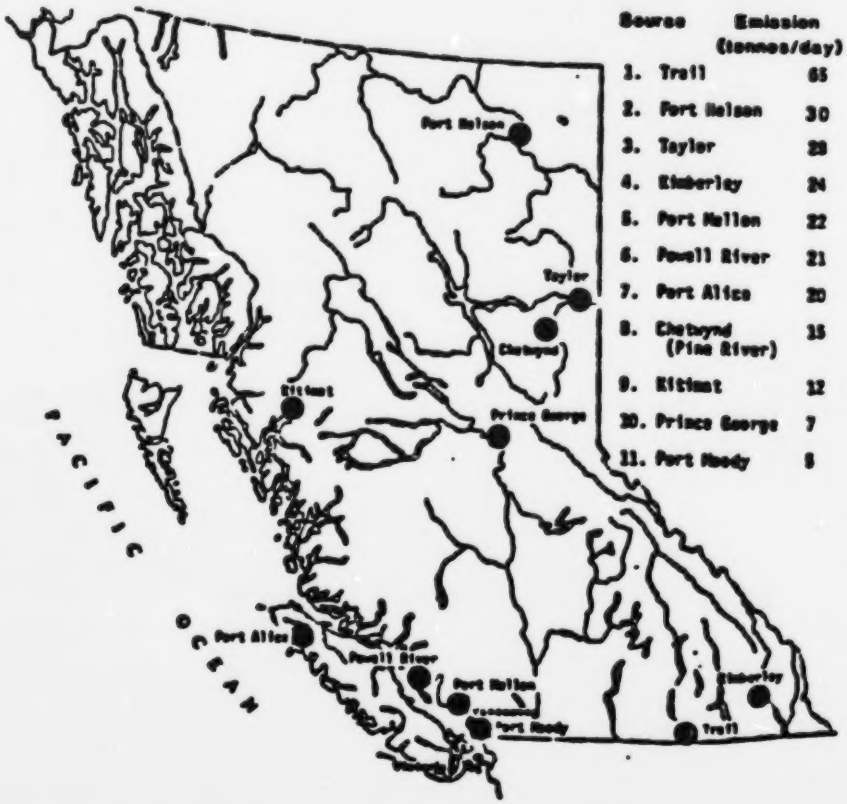
EMISSION INVENTORIES

The total sulphur dioxide emissions in British Columbia for five main source categories (1. industrial processes, 2. fuel combustion/stationary sources, 3. transportation, 4. solid waste incineration, and 5. miscellaneous) were estimated to be 205,000 tonnes in 1982.

There are eleven major point sources of sulphur dioxide which account for approximately 90,000 tonnes each year. The location of these major point sources and their annual emissions are indicated on the following map.

The sulphur dioxide emissions from Greater Vancouver and the Lower Mainland were estimated at 26,500 tonnes per year.

Major Point Sources of Sulphur Dioxide in British Columbia



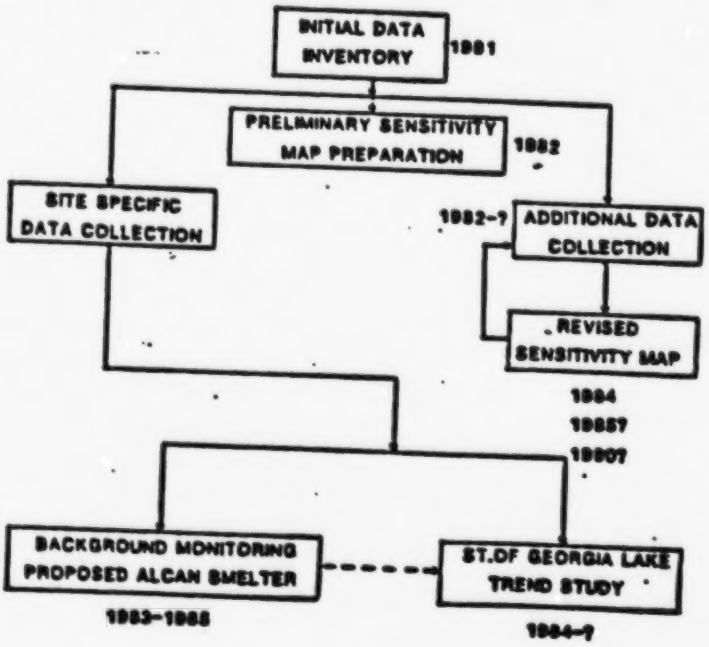
The total oxides of nitrogen emissions in British Columbia were estimated to be 176,500 tonnes per year for 1978. By source category the emissions of oxides of nitrogen were estimated to be (in tonnes/year):

- industrial processes	10,500
- fuel combustion/stationary	33,500
- transportation	123,500
- solid waste incineration	2,000
- miscellaneous	7,000

The oxides of nitrogen emissions from Greater Vancouver and the Lower Mainland were estimated to be 89,000 tonnes per year. Automobile emissions are the principal source for oxides of nitrogen in this area.

LAKE SENSITIVITY TO ACID RAIN

ACID RAIN LAKE SENSITIVITY
PROGRAM DEVELOPMENT



Mapping Lake Sensitivity - Initial Data Inventory

The British Columbia Ministry of Environment, through a coordinating committee established by the Technical Committee on Western Canada Long Range Transport of Atmospheric Pollutants, identified the data base for the period 1977 to 1981 for pH, aluminum, alkalinity, calcium and magnesium. The data base at that time consisted of 158 lakes with pH data, 107 lakes with alkalinity data, 130 lakes with calcium data, 129 lakes with magnesium data, and 17 lakes with aluminum data. Data for most characteristics were generally in the southern and central areas of the province.

It was determined that lake sensitivity mapping would use alkalinity and calcium data, and pH data would be mapped to indicate lake acidity. This is discussed in greater detail in Swain (1982).

Preliminary Sensitivity Map Preparation

During 1982, preliminary maps were prepared for lake acidity, using pH data and for lake sensitivity, using alkalinity and calcium data. The lake sensitivity maps were prepared as follows: high, moderate and low sensitivity areas were mapped for each of calcium and alkalinity; these maps were overlaid and a third map was produced which became the generalized lake sensitivity map.

Areas were classified on the generalized sensitivity map by using the rating which indicated the highest sensitivity from either the calcium or alkalinity maps. Classifications were based on the following criteria:

	Calcium (mg/L)	Alkalinity (mg/L $CaCO_3$)
High sensitivity	<4	<10
Moderate sensitivity	4-8	10-20
Low sensitivity	>8	>20

This is discussed in greater detail in Swain (1982).

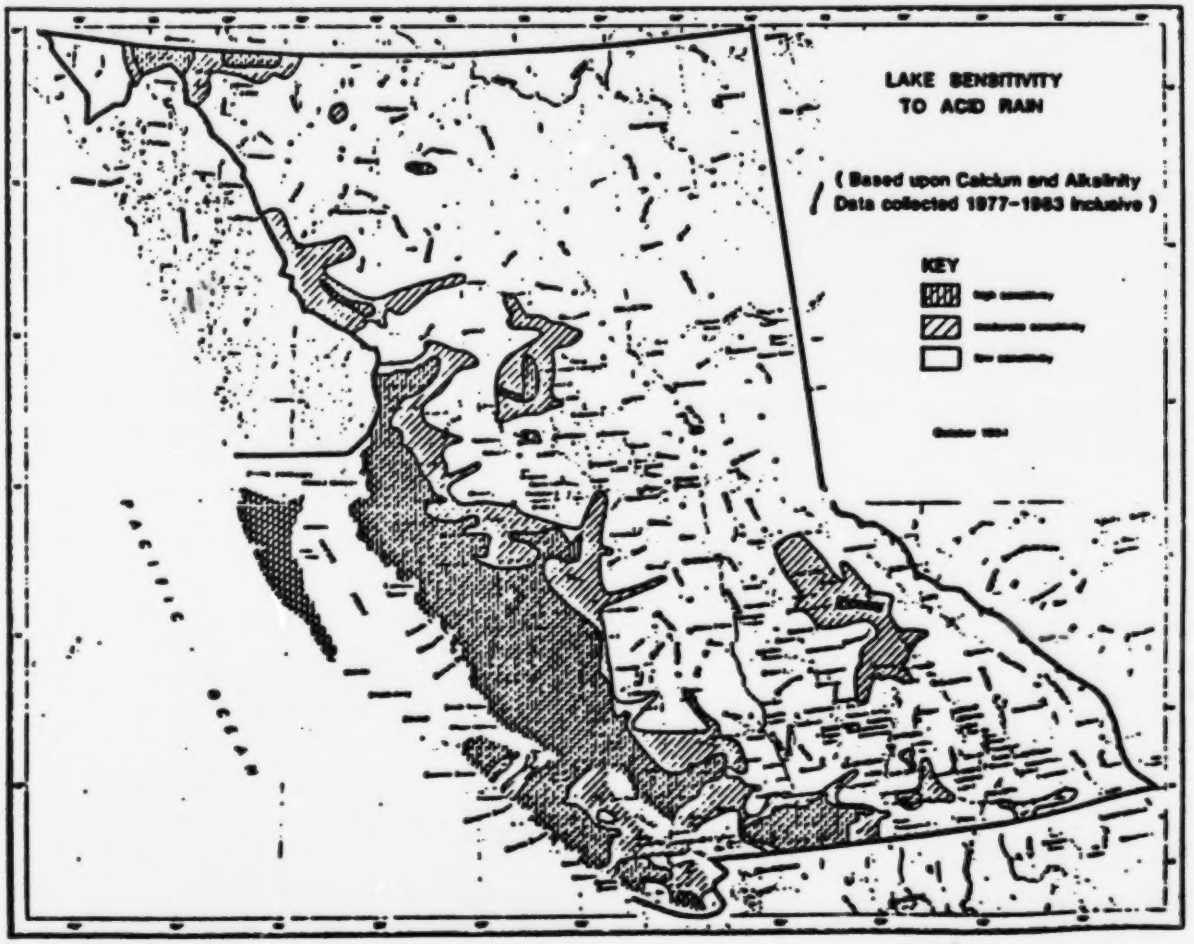
Additional Data Collection and Map Revision

Since 1982 the data base for lakes has grown by more than 100 lakes per year. Data are more spatially distributed. By the end of 1985, a data base will exist for more than 700 lakes. Characteristics for most of the post 1981 lakes were measured at two depths for pH, alkalinity, ions, nutrients and metals. Lakes sampled were well distributed throughout the province.

In early 1984, using data collected between 1977 and 1983, the lake sensitivity map which follows was prepared. It is anticipated that revisions to the map in the future will be refinements to boundaries rather than significant deviations from the general pattern (Swain, 1984).

Strait of Georgia Lake Trend Study

In 1984 a study was started in the Strait of Georgia area to complement the detailed precipitation chemistry monitoring. This study provides monthly measurements for a number of characteristics in nine lakes on southern Vancouver Island and the Lower Mainland area. The purpose of the study is to determine if acid rain is impacting sensitive lakes in this area. Water chemistry (pH, alkalinity, nutrients, ions, metals) is measured monthly, on a year-round basis, chlorophyll-a, zooplankton and phytoplankton are measured monthly from May to October, while aquatic vegetation is mapped and sediments are collected once every five years.



TERRESTRIAL SENSITIVITY TO ACIDIC INPUTS

Terrestrial sensitivity evaluations in British Columbia have emphasized mapping of sensitivity of soils and geology. It is recognized that both soils and geology can modify the acidity of acid precipitation thereby modifying the effects on receiving waters. It is also recognized that soils and geologic materials can themselves be altered by acidic inputs. Suitability as a medium for crop growth may therefore be affected. Sensitivity mapping has taken into account both of these aspects.

Several types of information are provided below. The process used to develop sensitivity maps is reviewed. Observations are made on the relative sensitivities of different areas of the province. Reference is also made to related acitivities and expected future directions.

Objectives of Sensitivity Mapping

Mapping of soil and geology sensitivity to acidic deposition is being done under the general sponsorship and endorsement of the Western Canada LRTAP Technical and Consultative Committees. Mapping has been done to provide focus for future monitoring and identification of areas for special attention. It has provided incentive for the compilation and analysis of inventory information from the perspective of impacts of acidic inputs. It has also resulted in development of information for British Columbia compatible with that of other western provinces and similar to that developed for Eastern Canada under the Memorandum of Intent (MOI) agreement with the U.S.

Preliminary Sensitivity Maps

Initial efforts in British Columbia resulted in two 1:6,000,000 and one 1:2,000,000 scale maps. The first was a generalized soil acidity map, grouping soils with similar pH values and derived by inferences from soil taxonomy. The second attempted to incorporate groupings of soils with similar buffering capacities as inferred from soil depth, upper and lower soil acidity, texture, and bedrock type. Neither was published or distributed. The third was based largely on groupings of soils with similar contents of exchangeable bases. Three sensitivity classes were defined. A more detailed review of available soil inventory data and laboratory analyses was carried out in preparation of this map. This map has had limited distribution but its use was interim pending preparation of maps using rating criteria consistent with those of other western provinces.

Soil and Geology Sensitivity Mapping - Western Canada LRTAP

Four basic steps have been involved in preparation of current sensitivity maps. These are: preparation/adaptation of a base map and legend suitable to interpretive rating for acidic input sensitivity, development and agreement on sensitivity rating criteria, application of criteria and rating of sensitivity of mapping units, and graphic presentation of maps at suitable scales.

A soils and geology base map was prerequisite to preparation of sensitivity maps. An existing, older, generalized soil map was updated using information from recent inventories. Mapping units were further defined on the basis of bedrock types. Mapping units were identified on the basis of dominant soil parent materials and described in terms of slopes, depth, texture, drainage, pH, exchangeable bases, cation exchange capacity, bedrock type, and soil taxonomy.

Criteria for two interpretive maps were adapted by Western Canada representatives. Both sets of criteria were based on those used in Eastern Canada under MOI. The first map is intended to show the capacity of the land to modify acidity of precipitation and its subsequent impact on aquatic systems. Rating criteria incorporate ability of both bedrock and overlying soils and surficial geology to neutralize acidic precipitation. Factors include: bedrock type (acidic to calcareous), extent of bedrock exposure or organic terrain, soil depth, soil bases etc. The second map is intended to portray the pattern of B.C. soils and their ability to resist chemical changes, due to acidic inputs, which would affect vegetation growth. Criteria were adopted for rating three important internal soil processes: soil acidification, base cation loss, and aluminum solubilization. Criteria were developed defining composite sensitivity classes based on ratings for these seperate processes. Primary soil factors defining sensitivity were soil pH and cation exchange capacity.

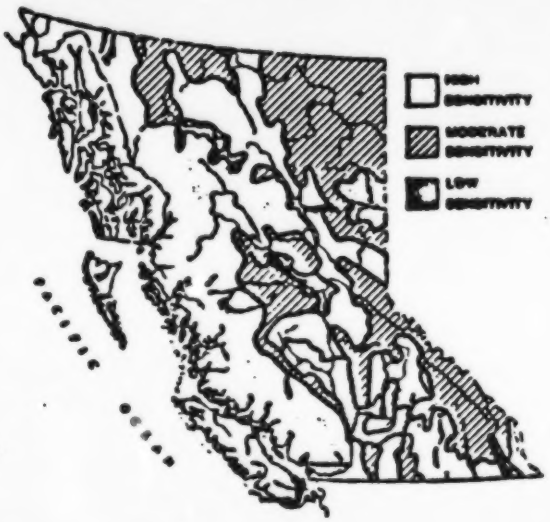
By applying the rating criteria to the mapping units of the soils and geology base map, four "potential to reduce acidity" groups, and three "sensitivity of soil to acidic inputs" groups were defined for the two maps respectively.

Along with the base map depicting soil areas, and the legend describing soil and geology of the areas, two maps were prepared which highlight each of the above indicated ratings using shading or patterning. A provincial publication will include maps at a 1:2,000,000 scale. Generalized maps as displayed at the Muskoka conference have also been prepared to show major areas of different potential or sensitivity.

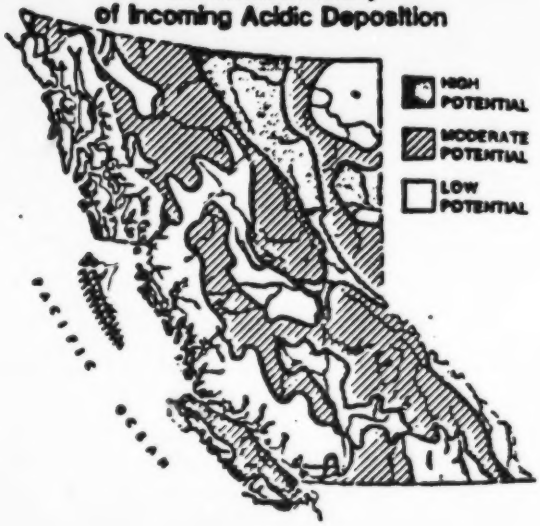
Preliminary Observations on Sensitivity

Interpretive maps are subject to final review and agreements on consistent rating at provincial and territorial boundaries. Review at this time, however, shows high potentials to reduce acidity in Rocky Mountain and foothill areas underlain by calcareous bedrock, in central B.C. areas with soils developed in fine textured materials, and in alkaline soil areas in the southern interior. Extensive areas with low potential are found in mainland coastal B.C. and the west coast of Vancouver Island, central and northern B.C., and southeastern mountainous areas. Ratings of high soil sensitivity to acidic inputs are extensive in the western coastal and mountainous areas of B.C., northern B.C., and west Kootenay areas. Low sensitivity is restricted largely to interior valley and fine textured soils. These patterns are depicted in the highly generalized very small scale maps below, similar to those at the Muskoka display.

Soil Sensitivity to Acidic Inputs



Potential of Soils and Geology to Reduce Acidity of Incoming Acidic Deposition



Other Related Activities

Information on actual buffering capacities of B.C. soils is limited. Laboratory buffer titration curves were therefore developed for over two hundred soil horizon samples from ten areas of the province. To explore ossible use of analytical soil data routinely collected during soil inventories, measures of buffering from the titration curves were statistically related to these parameters for the soils titrated. Predictive relationships were developed with varying success. A report is still in preparation.

Computer mapping and data manipulation methods have been applied to production of larger scale (1:25,000) soil sensitivity maps for the Fraser Valley of British Columbia. Several rating criteria have been used including sum of exchangeable bases, pH and cation exchange capacity combinations, and statistically predicted buffering capacities.

Future Activities

It is planned that increasing numbers of long-term monitoring sites will be established over the next few years. Soils will be sampled and acidic input sensitivity related parameters will be measured. Attempts will be made to establish trends due to acidic inputs changes and not simply due to seasonal or other short-term changes. Cooperation with the Acid Rain National Early Warning System (ARNEWS) is anticipated. Trend monitoring efforts will require critical evaluation of site selection, sampling methods, parameter selection, laboratory analytical methods, and data interpretation methods.

Ongoing review of sensitivity interpretation criteria is planned to allow possible future refinement of sensitivity maps. Research on environmental responses is to be scrutinized.

Evaluations will be made of the relationships between aquatic sensitivity and soil and geology sensitivity as depicted on the maps. A composite map or other presentation is planned.

DEPOSITION STANDARDS

The value of 20 kg/ha/y wet sulphate deposition was chosen to protect moderately sensitive lakes in eastern Canada. As such, it may not be appropriate in Western Canada. Because of the large areas of our environment that are highly or moderately sensitive, British Columbia is cooperating with the other Western Provinces and Environment Canada to review the latest scientific literature with a view towards establishing appropriate deposition standards for Western Canada. British Columbia has conducted a preliminary review of this issue, and one of the outcomes is a paper by C. Newcombe.

FUTURE INITIATIVES

An agreement for coordinated research activities in the period 1985-1988 has been signed by the Western Provinces and Environment Canada. In addition to the ongoing activities in precipitation chemistry monitoring, lake and terrestrial sensitivity assessments, British Columbia will be involved in the following new activities:

1. determination of criteria for acid deposition appropriate to Western Canada.

2. development/adaption of a medium range transport-deposition model.

3. assessment of the role of dry deposition in determining total acidic loading.

PUBLICATIONS

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FOR FURTHER INFORMATION

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